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An Application Related to Logistics Social Responsibility Evaluation with DEMATEL and ELECTRE Methods

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Abstract. The issue of environment becomes one of the privileged areas determined in the framework of social responsibility when national and international ethical scandals are experienced in various sectors. Therefore, to analyze activities of logistics firms in the framework of social responsibility theme gains importance while evaluating the activities in terms of their environmental effects. In regard to this important aspect, the purpose of this study is determined as to specify and prioritize the criteria which logistics firms should take into account while performing their social responsibility activities then to select the logistics firm which has the highest level of social responsibility. In this manner, DEMATEL method is used for weighting the criteria and ELECTRE method is used for firm selection. Analysis results show that "breakdown of fleet composition" criteria is the most important logistics social responsibility criteria while C firm has the highest level of social responsibility.
Keywords. Logistics, Social responsibility, Multi criteria decision making.
JEL. M10, M11, M14.

1. Introduction

Corporate social responsibility (CSS) is generally defined as a concept related to social requirements of carious activities which are done by an organization and social results of such activities (Matten & Moon, 2008). On the other hand,while defining the CSS concept Caroll (1979), as one of the leading researchers in this area, stated that organizations meet the community expectations with their economic, social, ethic and voluntary based activities. Additionally, as a result of environmental disasters occurred throughout the world, sustainability and environmental subjects have become important concepts which are mentioned together with corporate social responsibility in the recent years (Warhurst, 2001). Moreover, it is important that logistics firms should behave in the awareness of social responsibility for gaining community based legitimacy in order to decrease the negative environmental effect they cause while performing their activities.

Logistics Social Responsibility (LSR), which is a concept emerged through converting CSR activities to logistics and transportation sector, aims to create economic efficiency, social productivity and social diversity as paying attention to environmental and economic effects caused by logistics activities (Leon & Juan, 2014). The firms performing logistics activities such as purchasing, transportation, packaging, and storage should do their social responsibilities as taking into account

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such factors including environment, ethics, philanthropy, working conditions, security and urban transformation in addition to make profit or reduce their costs (Miao, 2012; Ciliberti et al., 2008). Given the criteria, LSR problem could be regarded as a multiple criteria decision making (MCDM) problem since it includes qualitative and quantitative factors. Considering not only the importance of LSR problem but also the structure of the problem; the purpose of this study is formed as to determine social responsibility criteria which logistics firms should pay attention while performing their activities and weight them with DEMATEL method, and secondly, with ELECTRE method to select the firm which has the highest level of social responsibility awareness among 3PL firms performing logistics activities of a firm which is in electronic industry in Turkey.

Literature related to LSR is provided in the following section of study which is composed of totally five sections. In the 3rd section, the methods used in the study are explained and in the 4th section, the case study in which the provided methods are applied is presented. In the last section, the results obtained through the study arehighlighted and suggestions for possible future studies are stated.

2. LiteratureReview

In this section of the study, the studies which focus on the social responsibility activities of logistics firms are provided.

Poist (1989) stated that LSR should be analyzed under the titles of labor force education, philanthropy, environment, urban transformation, work place diversity, health-security and community based issues. Besides, in their studies Carter & Jennings (2002) mentioned that social responsibility activities of logistics firms could be categorized into three main titles as purchasing, transportation and storage. They emphasized that each of the provided main titles should be studied in the sub-titles of environment, ethics, diversity, working conditions, human rights, security, philanthropy, and community participation. In their studies Murphy and Poist (2002) determined LSR factors and strategies. The analysis results show that minority and women employment are the most important factors. Süder (2005) analyzed social responsibility concept in supply chain through the titles of purchasing, unethical activities and child worker employment. In their studies Ciliberti et al. (2008) determined 47 LSR activities and aggregated them under main titles of purchasing, transportation, packaging, storage and reverse logistics. Conducting a progressive analysis for the combination of CSR and Supply Chain in their study, Hsueh & Chang (2008) determined that CSR applications increase the total profitability of supply chain according to the evaluation results taken from the sample composed of producers, distributors and suppliers. In the study that investigates the relationship between CSR and purchasing which is one of the logistics activities, Salam (2009) stated that purchasing social responsibility activities are affected from human based organizational culture, executive management, individual values of employees of purchasing department, labor force attempts, governmental regulations and customer pressures Ni et al. (2010) claimed that CSR performance in supply chain is rather dependent on supplier in the relationship of supplier and firm; then tested this claim with game theory. Sarkis et al. (2010) stated that the economic and environmental effects of applications of reverse logistics are generally focused in the literature. The stated study is differentiated from other studies as it analyzed reverse logistics in terms of social sustainability.In their studies, Miao et al. (2012) determined LSR stages as group culture, business ethics, customer pressure, supplier pressure, competitive firm pressure, and laws. Supporting their hypothesis, the results of their analysis on producer firms in China show that group culture and business ethics have the most

powerful effect on LSR stages. Ni & Li (2012) analyzed how CSR performance is affected by the relationship between supplier and producer firms. In their studies, Tamulis et al. (2012) determined the factors affecting firms' green logistics levels. According to their study, those factors are stated as "clean vehicles, multiple mode loading, loading consolidation, rad and traffic structure and delivery to address". Additionally, they provided that the factors determine the green logistics levels are also affected by "company, policies, customers and community" which are some of CSR stages. Cruz (2013) stated that the risks of global supply chain could be reduced with CSR activities. Nikolaou et al. (2013) offered a model utilizing the combination of CSR and sustainable reverse logistics activities. According to this model, the indicators of reverse logistics social responsibility could be aggregated to three main indicators as economic, environmental and social. Additionally, two different implementationwerecarried out in order to test the accuracy of the model. Çamlıca & Akar (2014) evaluated the importance of sustainability and the requirements to maintain the sustainability concept for logistics sector. Drobetz et al. (2014) determined that there is a positive direct relationship between CSR activities and financial performance of transportation firms. According to the analysis results, they offered the necessity of integrating CSR applications to strategic planning and operations for transportation firms. Halim et al. (2014) tested the relationship between reverse logistics adaptation levels and firm performance of producer firms in Malaysia. They presented that the factors which affect the reverse logistics adaptation process are affected by CSR applications. The results of the analysis show that the regulative policies are the factor which has the most powerful effect on reverse logistics activities. Leon & Juan (2014) studied the subject of CSR in logistics firms. They stated that the firms decreased both distribution costs and environmental effect while performing their distribution activities with social responsibility awareness. In the study of Hsueh (2015), trying to provide answers for the question of "Could the profitability of supply chain and individual profitability of companies be increased via CSR activities?", the results show that social responsibility awareness increases not only total profitability of supply chain but also individual profitability of companies in supply chain. Quarshie et al. (2015) conducted literature research in their studies which focus on sustainability in supply chain and CSR area. In their study, the articles published in "Business Ethics" and "Supply Chain Management" journals between the years of 2007-2013 are evaluated as theoretical and methodological. The results obtain in the study show the lack of synergy in this field. In this context, the need to interdisciplinary integrity is emphasized.

When the related literature is analyzed, it is found that only a few studies analyze social responsibility activities of logistics firms in Turkey. Additionally, it is observed that Multiple Criteria Decision Making (MCDM) methods were not utilized in those studies. On the other hand, in this study, the firm which has the highest level of social responsibility level among third party logistics firms which undertake an electronic producer firm's logistics activities operating in Turkey is analyzed with a model where DEMATEL and ELECTRE methods are integrated. In this direction, it is aimed to make contribution to the related literature.

3. Method

In this section, the methods used in this study are explained.

3.1. DEMATEL

The most important advantage offered by DEMATEL (The Decision Making Trial and Evaluation Laboratory) (Tzeng et al., 2007), which is one of the MCDM

method developed by Cenevre Battelle Memorial Institute between the years of 1972-1976 and used in solving complex and intertwined problems, is to enable organizing the criteria according to relationship types and priority in terms of importance on their effects on each other (Aksakal & Dagdeviren, 2010). This method is used to establish a network relationship between factors/ criteria (Yang et al., 2013) and composed of below listed steps (Tzeng et al., 2007; Aksakal & Dagdeviren, 2010; Yang & Tzeng, 2011; Yang et al., 2013):

Step 1: Establishing the Direct Relationship Matrix: Scores the decision maker group criteria as making binary comparison of direct relationship level on each other.

Table 1. *Binary Comparison Scale*

Numerical Values	*Definition*
0	Neutral
1	Low Effect
2	Medium Effect
3	High Effect
4	Very High Effect

Source: Aksakal & Dagdeviren, 2010:907

The 5-scale is generally used for this scoring as shown in Table-1. In the direction of the received answers, nxn sized matrixes are established in order to present the concept that which degree a_{ij} value i criterion of experts affect the j criterion. As taking average values of the established matrixes, direct relationship matrix $A=[a_{ij}]nxn$ is obtained.

Step 2: Establishing Normalized Direct Relationship Matrix: It is established as normalizing the direct effect matrix as using equation (1) and (2).

$$D = z \times A \tag{1}$$

$$z = 1 \Big/ \max\left\{\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right\} \tag{2}$$

Step 3: Establishing Total Relationship Matrix: Total effect matrix (T) is established as using equation (3). I in the equation stands for unit matrix

$$T = D + D^2 + \ldots + D^{\ell} \to \infty$$
$$= D\,(I-D)^{-1} \tag{3}$$

Step 4: Establishing Effect-Relationship Diagram as Determining Effect Directions: Assumingr_i is the total of rowsandc_j is the total of columns in T matrix, values of r_i-$c_j$andr_i+c_j are calculated. According to these calculations; the value of r_i+c_j shows the total of received and caused effects and determines the effect degree of the related criterion in the problem. On the other hand, r_i-c_j is used to observe the causer and receiver criteria. Depending on these effects, an effect-relationship diagram which depicts the relationships among criteria on a plane in DEMATEL method is established.

$$T = [\,t_{ij}]_{nxn}\,, \qquad i, j = 1, 2, \ldots, n \tag{4}$$

$$r = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} = [r_i]_{nx1} \tag{5}$$

$$c = \left[\sum_{i=1}^{n} t_{ij}\right]_{nx1} = [c_i]_{nx1} \tag{6}$$

3.2. ELECTRE

ELECRTE (Elimination Et Choix Traduisat la Realite) method developed by Roy and Vincke (1968) (Chatterjee et al., 2010) depends on binary superiority comparison among the alternatives for each evaluation criteria (Soner and Onut, 2006). The application steps of the method are as follows (Cho, 2003; Soner & Önüt, 2006):

Step 1: Establishing Decision Matrix: It is the initial matrix established by decision maker and alternatives are located in rows while criteria are located in columns. Accordingly, decision matrix (A_{ij}) is shows as following;

$$A_{ij} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{7}$$

Here, m shows the number of alternatives and n shows the number of criteria.

Step 2: Establishing Normalized and Weighted Normalized Decision Matrix: Decision matrix is firstly normalized and then heightened as using equation (8) and (9) in order.

$$v_{ij} = a_{ij} \Big/ \left(\sum_{t=1}^{n} a_{ij}^{2} \right)^{\frac{1}{2}}, \quad (i = 1,2,3,\ldots,n;\ j = 1,2,3,\ldots,m), \tag{8}$$

$$r_{ij} = w_j v_{ij}, \quad (i = 1,2,3,\ldots,n;\ j = 1,2,3,\ldots,m). \tag{9}$$

Step 3: Establishing Compliance and Non-Compliance Matrices: Assume that $f_j(i) = r_{ij}$ is the alternative performance value corresponding to j criterion. As j= 1, 2, 3,…, m and i≠k, compliance and non-compliance matrices are established as using equation (10) and (11) in order.

$$c(i,k) = \sum_{f_j(i) \geq f_j(k)} w_j, \quad (i,k = 1,2,3,\ldots n), \tag{10}$$

$$d(i,k) = \begin{cases} 0 & f_j(i) \geq f_j(k) \ \ if \\ \dfrac{\max\limits_{f_j(k) > f_j(i)} \left(f_j(k) - f_j(i) \right)}{\max\limits_{j} \left(\left| f_j(k) - f_j(i) \right| \right)} & otherwise \end{cases} \tag{11}$$

Step 4: Making Superiority Comparison: As $\bar{c}$ and $\bar{d}$ are the averages of compliance and non-compliance indeces, representatively;

$$A_i \rightarrow A_k \Leftrightarrow c(i,k) \geq \bar{c} \quad ve \quad d(i,k) \leq \bar{d}, \tag{12}$$

Here $A_i \rightarrow A_k$ notation shows that alternative i is superior over alternative k.

Step 5: Calculating Net Compliance and Net Non-Compliance Indexes: The values are calculated as using equation (13) and (14) in order.

$$\bar{c}_i = \sum_{k=1}^{n} c(i,k) - \sum_{k=1}^{n} c(k,i), \quad (i \neq k), \tag{13}$$

$$d_i = \sum_{k=1}^{n} d(i,k) - \sum_{k=1}^{n} d(k,i), \quad (i \neq k). \tag{14}$$

Step 6: Making Order: According to index values obtained through 5th step, alternatives are separately ordered and the final result is obtained as taking averages of these two ordering.

4. Application

Phases of the method applied in the application process of this study which aims to determine the firm which has the highest level of social responsibility among third party logistics firms which undertake logistics activities of a firm performing in electronic industry in Turkey as determining the importance level and relationship among logistics social responsibility criteria are shown in Graph-1.

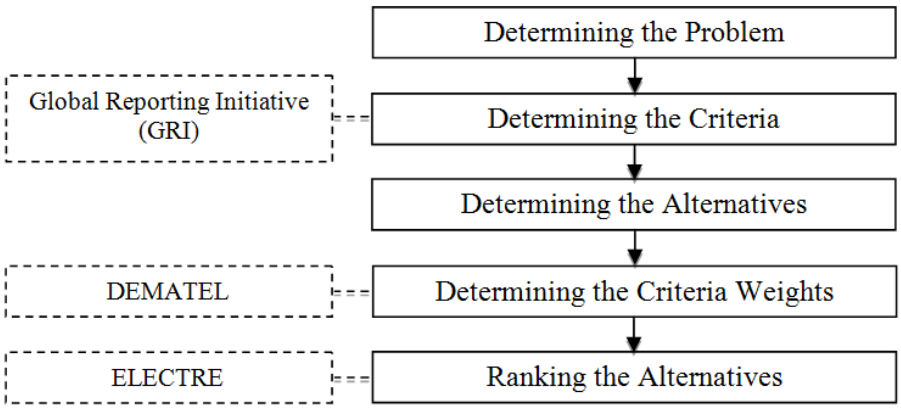

Figure 1. *Phases of Research Method*

4.1. Determiningthe Problem

The problems which are tried to be solved in this study could be presented under the following titles:

- Which criteria should logistics firms take into account in terms of social responsibility while performing their activities?
- What are the importance levels of such logistics social responsibility criteria?
- Which one of the 3PL firms, which undertake the logistics activities of a firm performing in electronic sector in Turkey, has the highest level of logistics social responsibility?

4.2. DeterminingtheCriteria

In the analysis of the related literature, it could be seen that various criteria including *labor force education andurban transformation* (Poist, 1989), *philanthropy,* (Poist 1989; Carter & Jennings, 2002), *environment, workingplace, diversity, health, security* and *community issues* (Poist, 1989; Carter & Jennings, 2002; Nikolaou et al., 2013), *work conditions* (Carter & Jennings, 2002), *human rights* (Carter & Jennings, 2002; Nikolaou et al., 2013), *sustainable purchasing, sustainable transportation, sustainable packaging, sustainable storage* and*reverse logistics* (Ciliberti et al., 2008), *raw material, energy* and*emission* (Miao et al., 2012) and *worker prevention* (Miao et al., 2012; Nikolaou et al., 2013) are considered in determination of logistics firms' social responsibility levels. Furthermore, Global Reporting Initiative (GRI) developed the criteria which could be used in determining logistics and transportation sector social responsibility levels and presented a report which firms could utilized as a guidance for providing a sustainable environmental performance (Leon & Juan, 2014). In this direction,

below stated criteria which are determined and also developed by GRI are used (Global Reporting Initiative Content Index, 2012):

- *(K_1):*Breakdown of fleet composition
- *(K_2):*Environmental effects of managerial policies and programs including using hybrid cars and developed route planning
- *(K_3):*Attempts to use renewable energy sources in order to increase the energy efficiency
- *(K_4):* Attempts to control the roadway based urban air emissions with the applications including alternative fuels, control frequencies of car maintenance and drivers' driving styles.
- *(K_5):*Policies and programs to eliminate traffic jam (including encouraging the distribution during the hours rather than rush hours, increasing the use rates of new transportation codes within cities and of alternative transportation modes).
- *(K_6):*Implementing policies and programs to decrease noise pollution
- *(K_7):* Environmental effects of organizations' assets and real estates related to transportation structure.

4.3. DeterminingtheAlternatives

This study's sample is composed of third party logistics firms which undertake logistics activities of a firm performing in electronic sector in Turkey. In this concept, seven amounts of firms are included into the sample and they are named as A, B, C, D, E, F and G in this study. According to the firms:

- They provide national and international services.
- They perform transportation, storage and distribution functions.
- They use road, air, maritime, rail and joint transportation modes.
- They offer value added services (including wrapping, packaging and labeling).
- They are the leading logistics firms of Turkey in terms of the information technologies they use.

4.4. DeterminingCriteriaWeights

In this section of the study, logistics social responsibility criteria which are developed by GRI are weighted by DEMATEL method which enables toinclude the interaction among criteria into the analysis. In this phase, DEMATEL survey was conducted on 3 academicians who conduct studies about logistics and social responsibility and 3 logistics firms' executives who work in the leading firms in Turkey. The direct relationship matrix which was obtained through using the equations 1-6 mentioned in the related section and criteria weights are provided in Table-2 in order.

Table 2.*Direct Relationship Matrix and Criteria Weights*

	Direct Relationship Matrix							
Criteria	*(K_1)*	*(K_2)*	*(K_3)*	*(K_4)*	*(K_5)*	*(K_6)*	*(K_7)*	*Weights*
(K_1)	0,00	3,00	1,50	2,50	2,00	2,50	2,00	*0,171*
(K_2)	0,00	0,00	1,50	3,00	1,00	2,00	1,50	*0,150*
(K_3)	3,50	2,50	0,00	3,50	0,00	1,00	1,50	*0,152*
(K_4)	2,00	2,00	1,50	0,00	0,00	1,00	1,00	*0,153*
(K_5)	2,00	1,00	0,00	2,00	0,00	2,00	1,00	*0,091*
(K_6)	2,50	1,50	1,50	1,00	1,00	0,00	1,50	*0,140*
(K_7)	2,00	2,50	2,50	2,00	0,50	2,00	0,00	*0,144*

In the analysis of Table-2, it can be said that "breakdown of fleet composition" of logistics firms have the highest importance. "Attempts to control the roadway based urban air emissions with the applications including alternative fuels, control frequencies of car maintenance and drivers' driving styles" criterion follows this criterion in terms of importance level. Policies and programs to eliminate traffic

jam (including encouraging the distribution during the hours rather than rush hours, increasing the use rates of new transportation codes within cities and of alternative transportation modes) is found out as the least important criterion.

4.5. RankingtheAlternatives

In this phase, ELECTRE survey is conducted on executives of seven amounts 3PL firms which perform logistics activities of a firm performing electronic sector. The decision matrix obtained through the survey responses is presented in Table-3. Additionally, logistics firms' ordering obtained using equations (7-14) provided in the related section of this study is presented in Table-3.

Table 3.*Decision Matrix and Firm Ordering*

Decision Index for Alternatives								Normalized Compliance Indices			
Logistics Firms	*Criteria*							*Net Compliance Index*	*Net Non-Compliance Index*	*Total Index*	*Rank*
	K1	K2	K3	K4	K5	K6	K7				
A	4	3	2	5	4	4	2	0,731	0,905	1,635	2
B	3	4	2	2	2	2	3	0,363	0,442	0,805	4
C	4	4	4	3	3	3	3	1,000	0,990	1,990	1
D	3	3	2	2	1	2	2	0,000	0,000	0,000	7
E	4	3	2	3	2	2	3	0,550	1,000	1,550	3
F	3	3	2	2	1	2	3	0,155	0,341	0,496	6
G	3	2	1	3	1	2	3	0,041	0,524	0,564	5

According to Table-3, C is the firm which has the highest level of logistics social responsibility. A and E firms follows in order. D is the firm which has the lowest level of social responsibility.

Sensitivity analysis is conducted in order to test whether the results change with differentiation of criteria weights. The results of ten different scenarios are presented in Table-4.

Table4. *Sensitivity Analysis*

Scenario	*Criteria Weights*							*Rank*
	K1	K2	K3	K4	K5	K6	K7	
Scenario 1	0,143	0,143	0,143	0,143	0,143	0,143	0,143	C-A-E-B-G-F-D
Scenario 2	0,090	0,150	0,152	0,153	0,171	0,140	0,144	C-A-E-B-G-F-D
Scenario 3	0,150	0,171	0,152	0,153	0,090	0,140	0,144	C-A-E-B-G-F-D
Scenario 4	0,144	0,140	0,090	0,153	0,152	0,150	0,171	C-A-E-B-G-F-D
Scenario 5	0,144	0,153	0,090	0,152	0,150	0,171	0,140	C-A-E-B-G-F-D
Scenario 6	0,153	0,090	0,144	0,140	0,171	0,152	0,150	C-A-E-B-G-F-D
Scenario 7	0,152	0,144	0,140	0,171	0,153	0,090	0,150	C-A-E-B-G-F-D
Scenario 8	0,140	0,171	0,152	0,150	0,144	0,153	0,090	C-A-E-B-G-F-D
Scenario 9	0,171	0,152	0,153	0,090	0,140	0,144	0,150	C-A-E-B-G-F-D
Scenario 10	0,090	0,140	0,144	0,150	0,152	0,153	0,171	C-A-E-B-G-F-D

According to Table-4, it can be stated that firm logistics social responsibility ordering does not change although criteria weights are differentiated. This shows that the results are not sensitive.

5. Conclusion

With constantly increasing environmental effects, public and private sector firms started re-constructing their systems and processes that they operate in compliance with sustainability approach which provide economic, environmental and social purposes together (Temur et al., 2015). Today's era in which environmental concerns of customers steadily increase in addition to legal regulations, firms have purposes to create an image of operating with the awareness of social responsibility in their activities for their customers.

Negative effects (including emission release, traffic jam and noise pollution) which may be caused by logistics activities depict that the problem of evaluating social responsibility levels of the firms which operate in this sector is important. Such problem is discussed in the literature under the title of logistics social responsibility (Leon & Juan, 2014). Accordingly, in the first section of this study, the criteria which should be considered in determination of firms' logistics social responsibility level are determined and in the second section of this study, where importance level of these criteria are analyzed, the firm is determined which has the highest level of social responsibility among 7 amounts of 3PL firms which undertake logistics activities of a firm performing in electronic sector in Turkey.

Accordingly, by taking into the related literature, the criteria suggested for determining social responsibility levels of the firms that operate in logistics and transportation sector by GRI are utilized in this study and DEMATEL method is used which enables the evaluation of relationships and interactions among criteria in their weighting. As a result of the analysis, it is found out that the criterion of "fleet composition specifications" has the highest importance. It can be said that this result correspond with the analysis of logistics social responsibility conducted in the study of Tamulis et al. (2012). Indeed, breakdown of fleet composition criterion which corresponds to the vehicle specifications (including amount of truck-van, amount of trailer truck, share of maritime-rail-air transportation in the total transportation) of logistics firms used during transportation activities have significant importance for determining social responsibility level. In the next phase, C firm is found out as the firm which has the highest level of logistics social responsibility level by using ELECTRE method. LF3 firm is differentiated from other firms with such policies that using smaller vehicles in distribution activities, making distribution activities during the off-peak traffic times. Therefore, it can be said that the above mentioned policies are effective on determination of C as the firm which has the highest level of logistics social responsibility level.

In this study, analyzing only the criteria which are suggested by GRI could be regarded as a limitation. In future studies, this limitation can be eliminated by creating the criteria for solving the logistics social responsibility problem with a decision making group consisted of representatives of the firms that get and provide logistics service, academicians experts in the field, representatives of non-governmental organizations and local authorities in addition to the related literature. Additionally, the aforesaid problem can be analyzed in the future studies through different multiple criteria decision making technics (Analytic Hierarchy Process, Analytic Network Process, VIKOR and TOPSIS etc.) or integrating fuzzy logic into these methods, and the results can be compared with findings of current study.

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